

Protein crystallization

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Nucleation, growth and perfection of protein crystals will be overviewed along with crystal mechanical properties. The knowledge is based on experiments using optical and force microscopies, light scattering, x-ray topography and diffraction, theory and modeling. Protein crystals behave similar to inorganic crystals, though with a difference in orders of magnitude in growing parameters. For example, the low incorporation rate of large biomolecules requires up to 100 times larger supersaturation to grow protein, rather than inorganic crystals.

Nucleation is often poorly reproducible, partly because of turbulence accompanying the mixing of precipitant with protein solution. Light scattering reveals fluctuations of molecular cluster size, its growth, surface energies and increased clustering as protein ages.

Growth most often occurs layer-by-layer resulting in faceted crystals. New molecular layer on crystal face is terminated by a step where molecular incorporation occurs. Quantitative data on the incorporation rate will be discussed. Rounded crystals with molecularly disordered interfaces will be explained.

Defects in crystals compromise the x-ray diffraction resolution crucially needed to find the 3D atomic structure of biomolecules. The defects are immobile so that birth defects stay forever. All lattice defects known for inorganics are revealed in protein crystals. Contribution of molecular conformations to lattice disorder is important, but not studied. This contribution may be enhanced by stress field from other defects. Homologous impurities (e.g., dimers, acetylated molecules) are trapped more willingly by a growing crystal than foreign protein impurities. The trapped impurities induce internal stress eliminated in crystals exceeding a critical size (part of mm for ferritin, lysozyme). Lesser impurities are trapped from stagnant, as compared to the flowing, solution. Freezing may induce much more defects unless quickly amorphysizing intracrystalline water.

Mechanical properties. No plasticity was found. For lysozyme, Young Modulus is 0.3 – 1 GPa from Bending experiments vs. ~ 3 GPa from ultrasound speed and light scattering. The discrepancy is explained by low mobility of viscous intracrystalline water.